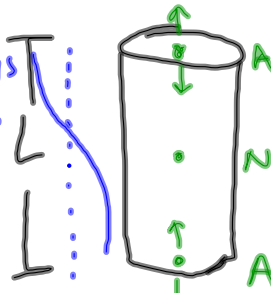


Standing Waves in Pipes:

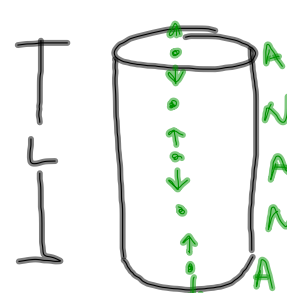
* Open/open: (both ends open)

* always antinodes at open ends of pipes



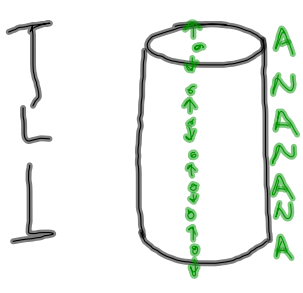
first harmonic

$$\lambda_1 = 2L$$

$$f_1$$


second harmonic

$$\lambda_2 = L$$

$$f_2 = 2f_1$$


third harmonic

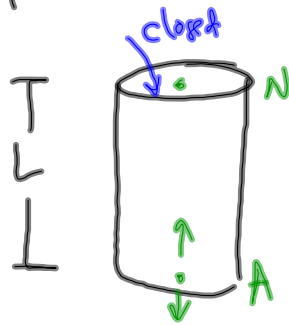
$$\lambda_3 = \frac{2}{3}L$$

$$f_3 = 3f_1$$

$$\lambda_n = \frac{2L}{n} \quad n=1, 2, 3, \dots$$

$$f_n = \frac{nv}{2L}$$

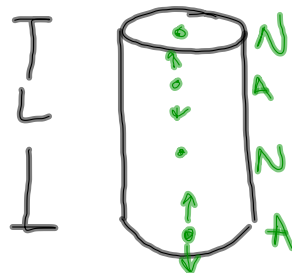
- Open/closed pipe



fundamental
harmonic

$$\lambda_1 = 4L$$

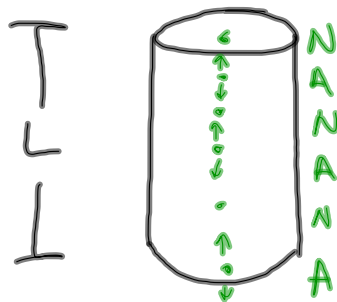
$$f_1$$



third harmonic

$$\lambda_3 = \frac{4}{3}L$$

$$f_3 = 3f_1$$



fifth harmonic

$$\lambda_5 = \frac{4}{5}L$$

$$f_5 = 5f_1$$

$$\lambda_n = \frac{4L}{n} \quad n = 1, 3, 5, \dots$$

$$f_n = \frac{nv}{4L}$$

Even harmonics do not exist!

Quiz Wednesday